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(54) **Creping adhesive composition**

(57) A creping adhesive composition useful in the production of soft paper products comprises:

(a) a major proportion of a vinyl acetate homopolymer or a copolymer in which the vinyl acetate units form at least 90% by weight of the polymer, the said homopolymer or copolymer having a molecular weight of from 500,000 to 1,500,000 and a glass transition temperature of from 28 to 36°C., and

(b) a minor proportion of polyvinyl alcohol having a molecular weight of up to 300,000, and

(c) a minor proportion of monosaccharide, an oligosaccharide, or a mixture thereof.

The adhesive composition is suitably used in the form of an aqueous dispersion for application to a creping drum.

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SPECIFICATION

Adhesive composition

The present invention relates to a creping adhesive composition, in particular to a creping adhesive composition suitable for application to a creping drum in an apparatus for producing soft, light-weight paper web suitable for making sanitary paper products such as bathroom and facial tissue, paper towels and napkins.

It is conventional practice to produce soft paper web by mechanically or chemically disrupting interfibre bonds in the paper web thereby to reduce the strength of the paper web. Examples of known methods of producing such softened paper web are to crepe paper web from a drying surface with a creping blade; to crepe paper web a second time after the web has been creped from a first drying surface; or to add chemical debonders to the fibrous material which forms the web. However, such conventional methods generally result in the production of paper webs having relatively low strengths for a given improvement in softness.

Compression of the paper web when it is wet encourages the formation of interfibre bonds, and a successful approach to the production of soft paper has been to minimise the formation of these bonds during manufacture of the web by avoiding mechanical compaction of the wet web at any stage thereby producing webs commonly referred to as "never-pressed" webs. In these processes, drying of the web is achieved using through-dryers which direct air through the web and it has been found that the internal structure of such "never-pressed" webs has an inherent bulk and softness which gains the maximum benefit from a subsequent creping step.

Consumer demands for still softer sanitary paper products have meant that it has become increasingly difficult to produce paper of the required softness from conventional equipment for making soft paper in which type of equipment the web is pressed to remove water and then creped from the surface of a Yankee dryer. Although better results have been achieved using the through-dryer technology discussed briefly above, such equipment is very expensive both to install and to operate. There has therefore been a substantial demand for methods of manufacturing soft paper which are capable of utilising conventional Yankee paper machines but which result in a softer product than has hitherto been possible to achieve on such equipment.

In an attempt to reach these desired quality levels, proposals have been made for adding a second creping stage to a conventional single-crepe Yankee paper machine, but generally these have not been successful in producing a light-weight sanitary tissue web having a basis weight in the range of 14–34 g/m² (8 to 20 lbs./2880ft²) and having the required degree of softness. Rather, paper of this weight produced on such machines has not generally exhibited the balance between softness and strength which is required for sanitary paper products.

We have developed a method of making a creped paper web which is comparable in softness and strength to "never-pressed" paper webs but which can be produced using conventional equipment incorporating mechanical de-watering and a Yankee dryer on which the web is dried and then creped.

This method, hereinafter referred to as our dual-creping method, is described and claimed in our co-pending British Patent Application No. 8401492. In that patent application we describe a method of making a soft paper web having a basis weight of from substantially 8 to 20 lb/2880ft² comprising the following sequence of steps:–

(a) forming a web from a slurry;

(b) applying the web to the surface of a Yankee dryer;

(c) creping the web from the surface of the Yankee dryer at a dryness of substantially between 93 and 97% by means of a first creping doctor;

(d) drawing the web from the creping doctor and treating the web to reduce the elasticity of the web introduced by said first creping step such that the mean square stretch of the web, as defined below, is not more than 9%;

(e) applying the web by means of an overall adhesive to a creping drum; and

(f) creping the web from the creping drum by means of a second creping doctor at a dryness of at least 93%.

The mean square stretch (MSS) of a paper web is defined by the equation:

$$MSS=\sqrt{MDS \times CDS}$$

where MDS is the percentage stretch in the machine direction and CDS is the percentage stretch in the cross-machine direction.

The creped paper web produced by the said method is comparable in softness and strength to "never-pressed" webs. An advantage of our dual-creping method is that the creped paper web can be produced using conventional equipment incorporating mechanical de-watering and a Yankee dryer on which the web is dried and then creped. This advantage results from the use of a dual creping process in which the first creping step is controlled so as to condition the

internal and surface structure of the web in such a manner that the creping response is maximised at the second creping stage. Such an arrangement is capable of producing soft paper at lower cost than apparatus using through-dryers to promote drying of the paper.

In order to optimise the performance of the second creping stage: i.e., the creping of the web from the creping drum, we have found that it is important that the web is strongly adhered to the creping drum over substantially its whole surface area, so that very high creping forces are employed to detach the web from the creping drum. Under such conditions, extensive disruption of the fiber to fiber bonding is achieved within a thin layer of the web which is in contact with the drum resulting in a significant improvement in the softness of that web surface. The remainder of the web is creped in a very fine pattern.

A problem arises in creping at the higher levels of adhesion attainable by the use of thermoplastic adhesives if the adhesive composition does not enable a uniform film of adhesive to be maintained on the creping drum. Adhesives which provide the desired high levels of adhesion tend to build up in thickness on the creping drum, usually in a non-uniform manner, resulting in variable adhesion and non-uniform product properties. Attempts to control the uniformity of the residual adhesive film by mechanical means as, for example, by frequent changes of the creping doctor blades, are undesirable because of the resulting adverse effect on machine operating efficiences.

A further problem arises in the use of thermoplastic adhesives in that portions of the adhesive which remain on the web surface after removal from the creping drum tend to cause the web to stick to itself as, for example, when the web is wound into rolls. This sticking of the web, termed "blocking", can interfere with the subsequent unwinding of the web from the roll. The extent of the blocking depends on the nature of the adhesive, the amount of adhesive retained on the web surface, the moisture content of the web, the contact pressure in the wound roll and the temperature. Blocking is decreased at lower temperatures. Some cooling of the web occurs naturally from the point of creping to the point of winding the web into a roll. Additional cooling of the web is possible at low cost by the forced application of air at ambient temperatures onto the web surfaces. When natural cooling or cooling with forced ambient air does not reduce the web temperature at the point of roll winding sufficiently to minimize or prevent blocking, it then becomes necessary to either utilize refrigeration systems to obtain further temperature reductions or to modify the adhesive composition to reduce its blocking tendency.

In our co-pending British Patent Application No. 8521828, we disclose an adhesive composition which provides the high creping forces needed to develop superior softness in creped webs and which provides for the development and maintenance of uniform adhesive films on the creping drum. The compositions of that Application are a blend of high molecular weight and low molecular weight thermoplastic polymers. The principal component is a high molecular weight polyvinyl acetate homopolymer or copolymer in which vinyl acetate comprises at least 90% by weight of the polymer. Minor amounts of a low molecular weight polyvinyl acetate homopolymer or copolymer are added to the principal component to obtain the uniform adhesive films on the creping drum needed for good machine performance. Such adhesives are preferred when the web can be wound into rolls at temperatures of 50°C. or less. When the web temperature exceeds 50°C., the web exhibits an increasing tendency to stick to itself when wound into rolls (i.e. an increasing degree of blocking). This results in an increasing difficulty in the subsequent unwinding of the web from the roll. Higher web temperatures occur in wound rolls when the ambient air temperatures are higher, when the machine speed is increased and when the basis weight of the web is greater. Under these conditions, it is advantageous to reduce the blocking tendency of the adhesive composition by adding materials which act to suppress blocking, thereby enabling rolls to be wound satisfactorily at higher temperatures without having to incorporate and maintain additional web cooling apparatus.

Accordingly, the present invention provides a thermoplastic creping adhesive composition comprising:

(a) a major proportion of a vinyl acetate homopolymer or a copolymer in which the vinyl acetate units form at least 90% by weight of the polymer, the said homopolymer or copolymer having a molecular weight of from 500,000 to 1,500,000 and a glass transition temperature of from 28 to 36°C., and

(b) a minor proportion of polyvinyl alcohol having a molecular weight of up to 300,000, and

(c) a minor proportion of a monosaccharide, an oligosaccharide, or a mixture thereof.

Component (a) in the compositions of the present invention is a high molecular weight polyvinyl acetate homopolymer or copolymer in which the vinyl acetate units comprise at least 90% by weight of the polymer. Molecular weights below 500,000 do not develop creping forces high enough to obtain the desired improvement in web properties, whereas molecular weights above 1,500,000 do not enable uniform films to be maintained on the creping drum.

Polymers which are either vinyl acetate homopolymers or copolymers containing at least 90% by weight of vinyl acetate will have glass transition temperatures between 28 and 36°C.

Component (b), polyvinylalcohol, is added as a blocking suppressant. Polyvinyl alcohol has,

however, the significant disadvantage of increasing the hardness of a thermoplastic creping adhesive when added in the amounts needed to suppress blocking. When polyvinyl alcohol is added to component (a), in amounts sufficient to suppress blocking, the resulting two-component mixtures do not enable uniform residual films to be maintained on the creping drum.

Accordingly, Component (c) is added as softening agent to reduce the hardness of the polyvinyl alcohol and mixtures thereof with component (a).

The usual means for softening polyvinyl alcohol is through the addition of plasticizers. Materials commonly employed for this purpose are low-molecular weight polyhydric alcohols, such as ethylene glycol, glycerol, propylene glycol, etc. Such plasticizers are not preferred for use in creping adhesive compositions because of their volatility at creping temperatures and their tendency to cause problems in the maintenance of films of sufficient thickness on the creping drum.

We have discovered that polyvinyl alcohol can be softened without the disadvantage of the common plasticizers by the addition thereto of monosaccharides, oligosaccharides or mixtures thereof. The common sugars, such as sucrose, glucose, maltose and fructose are typical examples of materials which can soften polyvinyl alcohol for use in the creping adhesives of this invention. Commercially available mixtures of saccharides of varying molecular weight have also been found useful. An example of such a mixture is a corn syrup food sweetener containing 35.5% D-glucose, 31.5% maltose, 14% trisaccharides, and 19% of higher order oligosaccharides.

The amount of component (b) required to suppress blocking in the adhesive compositions of this invention was found to vary from 10 to 30% by weight of all the components in the adhesive composition. Below 10%, the suppression of blocking is insufficient to be of significant value. Amounts greater than 30% are not needed to develop the required levels of suppression of blocking.

Polyvinyl alcohols having molecular weights of up to 300,000, preferably having a molecular weight of from 2,000 to 100,000 are suitable for use in the adhesives of this invention. The lower limit of molecular weight is determined by the weight at which the material loses its adhesive characteristics. The lower limit of molecular weight for the polyvinyl alcohols has not been established since polyvinyl alcohols having molecular weights below 2,000 are not generally available commercially. However, polyvinyl alcohol having a molecular weight of 2,000 has adequate adhesive qualities. The higher limit of molecular weight is determined by the method of application of the creping adhesive compositions. The preferred molecular weight for the preparation of aqueous dispersions of the creping adhesive of sufficiently low viscosity for effective application to the creping drum by spraying is up to 100,000. Polyvinyl alcohols having molecular weights above 100,000 yield solutions of high viscosities and are not preferred for the preparation of aqueous creping adhesive dispersions which are to be applied by spraying. However, polyvinyl alcohols having molecular weights up to 300,000 can be utilized in the present invention if other suitable means for applying high viscosity material are employed such as rotary roll printers or blade coaters.

Polyvinyl alcohols which are from 77 to 100% hydrolysed can be employed in the creping adhesives of this invention. Polyvinyl alcohols which are 88% hydrolysed tend to be softer and more easily dissolved in water than the fully hydrolysed material and are preferred.

We have found that the amount of component (c) required to soften polyvinyl alcohol for use in the creping adhesives of this invention may be varied from 50 to 200% by weight of the polyvinyl alcohol present in the adhesive. Amounts below 50% do not provide sufficient softening of the polyvinyl alcohol, whereas amounts in excess of 200% provide no further advantage in softening of the adhesive. It is desirable to use only the amount of monosaccharide, oligosaccharide or mixtures thereof which provides the necessary softening of the polyvinyl alcohol. Oligosaccharides tend to become discoloured at creping temperatures causing discolouration of the product, an effect which is greater when greater amounts are present in the creping adhesive.

The creping adhesives of the present invention are applied to the second creping drum of our dual creping process at from 0.12 to 0.3 grams of material solids per square metre of surface of the creping drum.

In using the creping adhesives of the present invention, we find that the creped web can be wound into rolls without problems from blocking at temperatures of up to 70°C.

We have found that the creping adhesive compositions of the invention have adhesive properties which are particularly well suited to the conditions of operation of our said dual-creping method, and in particular that the adhesive compositions are well suited for use in a said dual-creping method in which the temperature at the second creping drum is from 110 to 132°C.

The invention will now be illustrated by the following Examples.

In the Examples, percentages are by weight unless specified otherwise. The following properties of the paper web: machine direction tensile strength (MDT), machine direction stretch (MDS), cross-direction tensile strength (CDT), and cross-direction stretch (CDS), were measured in accor-

dance with TAPPI Standard T220M-60. The mean square stretch (MSS) has been defined above.

Basis weight (BW) is the weight per unit area of a sample of paper web expressed in g/m².

Bulk is measured using a Federal Bulk Tester which measures the thickness of 24 sample sheets under a load of 36.4 g/cm².

Handfeel (HF) is measured subjectively by a panel of individuals against standard samples having handfeel values assigned on an arbitrary scale from 10 (least soft) to 100 (softest).

The handfeel values quoted in the Examples are measurements made on the surface of the sheet which was in contact with the surface of the second creping drum.

In the Examples, a dual creping method and apparatus of the type described in our British Patent Application No. 8401492 was used to produce the creped web.

EXAMPLE I

Example I illustrates the improved attributes of a single-ply tissue product and the reduction in blocking attained by the use of creping adhesives of this invention.

A web is produced on a conventional fourdrinier paper machine from a pulp mixture comprising 88% softwood kraft and 12% secondary fibre. The web was pressed and dried on a Yankee dryer to 97% dryness just prior to creping. As creped from the Yankee dryer surface, the web had the following physical properties:

BW	25.4 g/m²
Bulk	0.297 cm/24 sheets
MDT	492 g/cm
MDS	9.3%
CDT	153 g/cm.
CDS	4.4%
MSS	6.4%

The web was then pressed onto a second creping cylinder. In accordance with the invention, a creping adhesive composition was applied to the cylinder as an aqueous dispersion containing 8% of total material solids using a spraying system. The material solids was a mixture of 80% high molecular weight polyvinyl acetate (molecular weight=750,000), 10% polyvinyl alcohol (molecular weight=25,000) and 10% sucrose. The web and creping adhesive was dried and heated to a temperature of 122°C. just prior to creping. The cylinder was operated at a speed of 12.7 m/sec. The web was then creped from the cylinder using a creping blade angle of 2° above the cylinder radial line. The properties of the resulting product are given in the following Table:

BW	30.8 g/m²
Bulk	0.579 cm/24 sheets
MDT	314 g/cm
MDS	24.1%
CDT	132 g/cm
CDS	9.2%
HF	87
Blocking	0.34 g/cm

The softness of the creped web produced in this example as measured by a handfeel (HF) rating of 87 is substantially greater than the handfeel ratings of 35 to 55 normally obtained in single-ply creped webs.

Blocking is measured in the following manner. Samples of the web are placed such that the surface of a web which was in contact with the creping cylinder and creping adhesive is placed over the surface of a second web which was not in contact with the creping dryer. The pair of webs is then pressed together with a pressure of 210 g/cm² for a period of 2 hours at a temperature of 65°C. The pressure is removed and the sample is allowed to cool and reach moisture equilibrium in an atmosphere of 50% relative humidity at 23°C. The force required to separate the webs is then measured at a peeling rate of 1.27 cm/sec.

A dual creped web was produced using the same Yankee creped web described above, but with a creping adhesive composition, containing no blocking suppressants, and consisting of 70% high molecular weight polyvinyl acetate (molecular weight=750,000) and 30% low molecular weight polyvinyl acetate (molecular weight=125,000). All other conditions were held constant in the second creping step. This web had the following physical properties:

BW	28.6 g/m²
Bulk	0.541 cm/24 sheets
MDT	106 g/cm
MDS	24.6%
CDT	48 g/cm
CDS	10.7%
HF	90
Blocking	0.47 g/cm

The reduction in blocking from 0.47 to 0.34 g/cm has a significant effect on the degree of blocking noted in the unwinding of rolls of web produced on the paper machine. It is attained in this invention without loss of web attributes compared to product produced with polymers containing no blocking suppressants.

Example II

The following example illustrates the result obtained with the invention when greater reductions in blocking were desired.

A web is made on a conventional fourdrinier paper machine from a pulp mixture of 50% northern softwood kraft and 50% eucalyptus kraft. The wet web is pressed and dried on a Yankee dryer. It is then creped from the Yankee dryer surface following conventional dry crepe practice. The properties of this web are given in the following Table:

BW	32.2 g/m²
Bulk	0.376 cm/24 sheets
MDT	280 g/cm
MDS	8.3%
CDT	124 g/cm
CDS	5.0%
MSS	6.4%

This web was then pressed onto a second creping cylinder at a dryness of 95%. The creping cylinder was coated with a creping adhesive composition in the form of a film which provides the adhesion between the web and the cylinder surface. The creping adhesive material was applied to the dryer as an aqueous dispersion containing 8% solids by spraying at a rate of 0.25 grams of material solids per square metre of cylinder surface. The material solids was a mixture of 50% of high molecular weight polyvinyl acetate (molecular weight 1,200,000), 25% polyvinyl alcohol (88% hydrolysed, 25,000 molecular weight) and 25% sucrose. The web and adhesive film were dried and heated to a temperature of 113°C. just prior to the creping blade. The speed of the creping cylinder was 10.2 m/sec. The web was then creped from the cylinder using a creping blade angle of 2° above the cylinder radial line. The physical properties of the resulting web are given in the following Table:

BW	36.7 g/m²
Bulk	0.699 cm/24 sheets
MDT	163 g/cm
MDS	20.3%
CDT	79 g/cm
CDS	8.6%
HF	83
Blocking	0.09 g/cm

This product has the excellent bulk, handfeel, and stretch properties which are attained with the invention. The blocking value of 0.09 g/cm is significantly lower than the usual values of 0.45 to 0.6 g/cm obtained using creping adhesives based on mixtures of polyvinyl acetate homopolymers or copolymers. Blocking values in the range of 0.2 g/cm or less enable webs to be wound into rolls at temperatures of up to 70°C. without encountering difficulty in subsequently unwinding the roll.

EXAMPLE III

A web is produced on a conventional fourdrinier paper machine from a pulp mixture comprising 87% northern softwood kraft and 13% secondary fiber. The web was pressed and dried on a Yankee dryer to 96% dryness just prior to creping. The web creped from the Yankee dryer surface had the following physical properties:

BW	18.6 g/m²
Bulk	0.21 cm/24 sheets
MDT	152 g/cm
MDS	8.7%
CDT	70 g/cm
CDS	6.0%
MSS	7.2%

This dry web was then pressed onto a second creping cylinder. The creping cylinder was coated with a creping adhesive composition which provides the adhesion between the web and cylinder surface. The creping adhesive material was sprayed onto the cylinder surface as an aqueous dispersion containing 8% of material solids at the rate of 0.25 grams of material solids per square metre of cylinder surface. The material solids was a mixture of 52% high molecular weight polyvinyl acetate (molecular weight 1,200,000), 16% polyvinyl alcohol (88% hydrolysed, 25,000 molecular weight) and 32% of a mixture of saccharides contained in corn syrup. The corn syrup composition was 35.5% D-glucose, 31.5% maltose, 14% trisaccharides and 19% of higher order oligosaccharides. The web and adhesive film were dried and heated to a temperature of 116°C just prior to the creping blade. The web was then creped from the cylinder at a speed of 10.2 m/sec. using a creping blade angle of 4° above the cylinder radial line. The resulting creped web was then combined into a two-ply product with those surfaces which had been in contact during creping with the second creping cylinder facing outward. This two-ply product had the following physical properties:

BW	42.0 g/m²
Bulk	0.80 cm/24 sheets
MDT	188 g/cm
MDS	25.6%
CDT	99 g/cm
CDS	11.8%
HF	95
Blocking	0.26 g/cm

These examples illustrate the superior softness attainable in webs produced by the practice of this invention. The softness effect is greatest in the surface of the web which has been in contact with the second creping drum. Hence, the greatest product improvement is attained in the manufacture of two-ply tissue products in which the softer surface of each of the two plies is turned outward. In one-ply tissue webs, only one of the surfaces will have the superior softness.

CLAIMS

1. A creping adhesive composition comprising:

(a) a major proportion of a vinyl acetate homopolymer or a copolymer in which the vinyl acetate units form at least 90% by weight of the polymer, the said homopolymer or copolymer having a molecular weight of from 500,000 to 1,500,000 and a glass transition temperature of from 28 to 36°C., and

(b) a minor proportion of polyvinyl alcohol having a molecular weight of up to 300,000, and

c) a minor proportion of a monosaccharide, an oligosaccharide, or a mixture thereof.

2. A creping adhesive composition according to Claim 1, wherein the amount of component (b) is from 10 to 30%, on a dry solids basis, based on the weight of all the components in the adhesive composition.

3. A creping adhesive composition according to Claim 1 or 2, wherein the polyvinylalcohol is a polyvinylalcohol which is from 77 to 100% hydrolysed.

4. A creping adhesive composition according to Claim 3, wherein the polyvinylalcohol is 88% hydrolysed.

5. A creping adhesive composition according to any one of the preceding claims, wherein the amount of component (c) is from 50 to 200% by weight, based on the weight of component (b).

6. A creping adhesive composition according to any one of the preceding claims, wherein the oligosaccharide is a disaccharide.

7. A creping adhesive composition according to Claim 6, wherein the disaccharide is sucrose, or maltose.

8. A creping adhesive composition according to any one of Claims 1 to 5, wherein the monosaccharide is glucose, or fructose.

9. A creping adhesive composition according to any one of Claims 1 to 5, wherein compo-

nent (c) is a corn syrup comprising 35.5% by weight D-glucose, 31.5% by weight maltose, 14% trisaccharides, and 19% by weight higher order oligosaccharides.

10. A creping adhesive composition according to any one of the preceding claims, wherein the polyvinyl alcohol is a polyvinyl alcohol having a molecular weight of from 2,000 to 100,000.

11. A creping adhesive composition substantially as claimed in Example I, Example II or Example III.

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